THE SMOKE PROBLEM

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This article was broadcast as an informal talk, October 16, 1928, from Radio Station W.E.A.O. by F. W. Marquis, Professor of Steam Engineering at The Ohio State University. The author did not intend to offer a technical solution for our smoke problem, but rather to point out the general causes and effects of the smoke nuisance. It is a problem which concerns all of us at the present time.— EDITOR.

The problem of smoke abatement is an old one. We are told that Edward the First prohibited the use of coal in London because of the "unsavory vapors therefrom"; that in 1600, or thereabouts there was a smoke commission in London, and that more or less continuously since that time much attention has been given to that problem. In spite of all this, London has the reputation of being a very smoky city. The problem is evidently a difficult one. Perhaps Edward the First had the right idea when he prohibited the use of coal. If we burned no coal we should not be bothered greatly with smoke. But, for obvious reasons, we do not hear anyone suggesting that solution.

The term "smoke" as here used is meant to include all the products of combustion which are discharged into the atmosphere. Some fuels, such as anthracite coal and coke, are low in volatile matter and burn without appreciable visible smoke, although small particles of ash may be carried off. Other fuels, such as the high volatile bituminous coals which are most easily available to us in Ohio, are apt to be bad smoke producers, as liquid fuels may also be under some conditions. The smoke from such fuels may contain such things as soot, or carbon in finely divided form, tar, particles of ash, sulphur acids, and ammonia compounds. Such smoke will cause a large amount of damage. It makes the job of keeping ourselves, our clothing, and our buildings clean a difficult and expensive one. It may hasten the destruction and weathering of certain kinds of stone and other building material. It has an active corrosive action on some metals. It may increase the cost of illumination, not only by absorbing the light in its passage through the atmosphere, but also because of soot coating skylights, windows, and lighting fixtures. It injures vegetation and doubtless affects the mental state, personal efficiency, and health of the individual.

Mr. H. B. Meller, of the Mellon Institute of Industrial Research, says, in a recent paper, that the preventable money loss per capita per annum in a smoky city has been variously estimated to be from $10 to $20. This is made up of the additional cost of laundry work, clothes, cleaning, redecorating, repainting, shorter life of certain building materials, damage to merchandise, loss due to improper combustion of fuel, etc. It does not include any allowance for the indefinite but real loss due to the detrimental effects upon the health and psychology of the community, and no allowance is made for that amount of money which might reasonably compensate a resident in a smoky city for what Mr. Meller calls "the disagreeableness of it all."

There certainly can be no question about the undesirableness of smoke. It is a nuisance from every point of view. But the question which immediately arises is whether this nuisance is a necessary one. Before attempting to answer this question, it would be profitable to consider briefly the process of combustion.

When a fuel burns there is a chemical union of the combustible matter in the fuel and the oxygen in the air. Matter cannot be destroyed; therefore all the elements in the fuel, together with those in the air used, will be present in the products of combustion, after the fuel has been burned. If the combustion has taken place under proper conditions, so that all the combustible matter has been completely burned, the products of combustion will be less objectionable than they would be if incompletely or only partly burned. The best that can possibly be done is then to burn the fuel under such conditions that combustion will be complete.

There are three fundamental conditions which are necessary for complete combustion. First, a sufficient amount of air must be supplied. This amount is always somewhat more than necessary for complete oxidation of all the combustible matter. Second, the air must be thoroughly mixed with the combustion gases and the small particles of fuel floating above the fuel bed; and third, the temperature must be high enough to cause ignition, and the gases must not be cooled below this temperature until there has been time enough for combustion to become complete.

It is a comparatively simple matter to control things so that these conditions are met when gas, or even fuel like anthracite coal, is being burned; but difficulty develops when bituminous coal is the fuel used. One of the distinguishing characteristics of bituminous coal is that a large amount of gas and tar vapors are distilled off when it is heated. High volatile coals give off a greater amount of such gas than those known as low volatile. This gas, if cooled and condensed without being burned, would form dense smoke.

Let us consider what happens when a fresh charge of bituminous coal is thrown into a boiler furnace on to a hot fuel bed. As the coal rapidly heats up, an enormous volume of these combustible gases, known as volatile matter, is driven off. If these gases are to be properly burned, a correspondingly large amount of air must be supplied, since it takes about fifteen pounds of air to burn one pound of the volatile matter. Moreover, the air and gases must be intimately mixed, and the mixture must remain in the hot part of the furnace until burning is complete. If sufficient air is not supplied, if the mixture is not intimate enough, or if sufficient time is not allowed for the mixture to burn before the gases strike the relatively cold parts of the boiler and are cooled below ignition temperature, then dense, black, tarry smoke will result. After the volatile gases have been driven off, the solid part of the fuel, known as fixed carbon, is burned. This is a much slower process, and the air should therefore be supplied at a much lower rate during this period. This requirement for large and variable air supply is

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one of the things which makes the smokeless burning of bituminous coal so difficult. The large volume of gases makes large furnace volumes necessary and increases the difficulty of mixing.

In the small domestic heating furnace, the problem is especially difficult. Whoever is in charge of the heating plant usually spends a small fraction of his time in firing, and knows very little about firing methods. He usually puts in enough coal at one time to last for a considerable period, perhaps several hours. This comparatively large amount of coal tends to cool the whole furnace, with the result that a large part of the combustible gas distilled off is never heated to ignition temperature. In addition to this, in many cases, even if enough air is supplied, the mixing is not complete enough. The result is, of course, smoke, plenty of it. Much of the smoke which we complain about comes from our own heating furnaces, and will probably continue to do so as long as we continue to burn high volatile bituminous coal.

In hand-fired industrial boiler furnaces, the problem is a different one. Here a regular fireman is employed, whose duties are, mainly, if not entirely, limited to firing. The temperatures in the furnace are much higher than they are likely to be in domestic heating plants, and relatively much less coal is fired at a time, the firing periods being close together. However, there is apt to be much trouble with the proper admission and mixing of air. If the furnace is sufficiently large and properly designed, it should be possible, if proper firing methods are used, to operate without much smoke. If the load is variable, or very heavy, smokeless operation is more difficult; and if proper firing methods are not used, smoke is bound to result even with the best of equipment.

One of the principles which should be followed in hand firing is to fire often and light—that is, a small amount of coal at a time. If the coal could be supplied at a uniform rate, the volatile gases would be distilled off at a uniform rate and the problem of supplying and mixing air would be simplified. Just here is one of the places wherein the automatic stoker has the advantage, for it does feed the coal into the furnace at nearly a uniform rate. Moreover, it relieves the fireman of much of his work. The job of successful firing has less of the human element in it, but some still remains. There are many stoker installations which can burn high volatile coals with little or no objectionable smoke, but which will produce smoke if not properly operated. And there are, of course, many other stoker installations which are not properly made, and which are very difficult to operate without smoke.

In conclusion, the question as to whether the smoke nuisance is a necessary one or not might well be answered as follows: The smoke problem is a difficult one. However, the amount of smoke produced can be greatly lessened if proper equipment is provided and if it is properly used. This will take continual effort. If we stop combating the smoke nuisance, it will get worse. We shall always have smoke as long as we continue to burn high volatile bituminous coal in its raw state; but the smoke nuisance can be abated, if not eliminated.